

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problem Mailbox.**



PHGB010056
USA
I-II



INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ



I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated

12 JUN 2001



The
Patent
Office

1/77

08AUG00 1558914-1 003008
P017700 0700-0019335.9

Request for grant of a patent
(See notes on the back of this form. You can
also get an explanatory leaflet from the Patent
Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference

PHGB 000105

2. Patent application number
(The Patent Office will fill in this part)

0019335.9

8 AUG 2000

3. Full name, address and postcode of the or of
each applicant (underline all surnames)

KONINKLIJKE PHILIPS ELECTRONICS N.V.
GROENEWOUDSEWEG 14
5621 BA EINDHOVEN
THE NETHERLANDS

Patents ADP Number (if you know it)

7419294001

If the applicant is a corporate body, give the
country/state of its incorporation

THE NETHERLANDS

4. Title of the invention

WIRELESS TERMINAL

5. Name of your agent (if you have one)

KEVIN JAMES SCOTT

"Address for service" in the United Kingdom
to which all correspondence should be sent
(including the postcode)

Philips Corporate Intellectual Property
Cross Oak Lane
Redhill
Surrey RH1 5HA

Patents ADP number (if you know it)

7688914001

6. If you are declaring priority from one or more
earlier patent applications, give the country

Country

Priority Application number, Date of filing

and the date of filing of the or of each of these
earlier applications and (if you know it) the or
each application number

7. If this application is divided or otherwise
derived from an earlier UK application, give
the number and the filing date of the earlier
application

Number of earlier application

Date of filing
(day/month/year)

8. Is a statement of inventorship and of right to
grant of a patent required in support of this
request? (Answer "Yes" if:

YES

- a) any applicant named in part 3 is not an inventor, or
 - b) there is an inventor who is not named as an
applicant, or
 - c) any named applicant is a corporate body.
- See note (d))

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form.
Do not count copies of the same document.

Continuation sheets of this form

Description

Claims(s)

Abstract

Drawings

ONLY

10. If you are also filing any of the following, state how many against each item:

Priority Documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patents Form 9/77)

Request for substantive examination

(Patents Form 10/77)

Any other documents

(Please specify)

11. I/We request the grant of a patent on the basis of this application.

Signature

Date

7th August 2000

12. Name and daytime telephone number of person to contact in the United Kingdom

01293 81 5281

K J SCOTT

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

- If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.
- Write your answers in capital letters using black ink or you may type them.
- If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.
- If you have answered "Yes" Patents Form 7/77 will need to be filed.
- Once you have filled in the form you must remember to sign and date it.
- For details of the fee and ways to pay please contact the Patent Office.

DESCRIPTION**WIRELESS TERMINAL**

The present invention relates to a wireless terminal, for example a
5 mobile phone handset.

Wireless terminals, such as mobile phone handsets, typically
incorporate either an external antenna, such as a normal mode helix or
meander line antenna, or an internal antenna, such as a Planar Inverted-F
10 Antenna (PIFA) or similar.

Such antennas are small (relative to a wavelength) and therefore, owing
to the fundamental limits of small antennas, narrowband. However, cellular
radio communication systems typically have a fractional bandwidth of 10% or
more. To achieve such a bandwidth from a PIFA for example requires a
15 considerable volume, there being a direct relationship between the bandwidth
of a patch antenna and its volume, but such a volume is not readily available
with the current trends towards small handsets. Hence, because of the limits
referred to above, it is not feasible to achieve efficient wideband radiation from
small antennas in present-day wireless terminals.

20 A further problem with known antenna arrangements for wireless
terminals is that they are generally unbalanced, and therefore couple strongly
to the terminal case. As a result a significant amount of radiation emanates
from the terminal itself rather than the antenna.

25 An object of the present invention is to provide a wireless terminal
having efficient radiation properties over a wide bandwidth.

According to the present invention there is provided a wireless terminal
comprising a ground conductor and a transceiver coupled to an antenna feed,
wherein the antenna feed is coupled directly to the ground conductor.

30 The present invention is based upon the recognition, not present in the
prior art, that the impedances of an antenna and a wireless handset are similar
to those of an asymmetric dipole, which are separable, and on the further

recognition that the antenna impedance can be replaced with a non-radiating coupling element.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, wherein:

Figure 1 shows a model of an asymmetrical dipole antenna, representing the combination of an antenna and a wireless terminal;

Figure 2 is a graph demonstrating the separability of the components of the impedance of an asymmetrical dipole;

Figure 3 is an equivalent circuit of the combination of a handset and an antenna;

Figure 4 is an equivalent circuit of a capacitively back-coupled handset;

Figure 5 is a perspective view of a basic capacitively back-coupled handset;

Figure 6 is a graph of simulated return loss S_{11} in dB against frequency f in MHz for the handset of Figure 5;

Figure 7 is a Smith chart showing the simulated impedance of the handset of Figure 5 over the frequency range 1000 to 2800MHz;

Figure 8 is a graph showing the simulated resistance of the handset of Figure 5;

Figure 9 is a perspective view of a narrow capacitively back-coupled handset;

Figure 10 is a graph showing the simulated resistance of the handset of Figure 9;

Figure 11 is a perspective view of a slotted capacitively back-coupled handset;

Figure 12 is a graph of simulated return loss S_{11} in dB against frequency f in MHz for the handset of Figure 11; and

Figure 13 is a Smith chart showing the simulated impedance of the handset of Figure 5 over the frequency range 1000 to 2800MHz.

In the drawings the same reference numerals have been used to indicate corresponding features.

Figure 1 shows a model of the impedance seen by a transceiver, in transmit mode, in a wireless handset at its antenna feed point. The impedance is modelled as an asymmetrical dipole, where the first arm 102 represents the impedance of the antenna and the second arm 104 the impedance of the handset, both arms being driven by a source 106. As shown in the figure, the impedance of such an arrangement is substantially equivalent to the sum of the impedance of each arm 102,104 driven separately against a virtual ground 108. The model could equally well be used for reception by replacing the source 106 by an impedance representing that of the transceiver, although this is rather more difficult to simulate.

The validity of this model was checked by simulations using the well-known NEC (Numerical Electromagnetics Code) with the first arm 102 having a length of 40mm and a diameter of 1mm and the second arm 104 having a length of 80mm and a diameter of 1mm. Figure 2 shows the results for the real and imaginary parts of the impedance ($R+jX$) of the combined arrangement (Ref R and Ref X) together with results obtained by simulating the impedances separately and summing the result. It can be seen that the results of the simulations are quite close. The only significant deviation is in the region of half-wave resonance, when the impedance is difficult to simulate accurately.

An equivalent circuit for the combination of an antenna and a handset, as seen from the antenna feed point, is shown in Figure 3. R_1 and jX_1 represent the impedance of the antenna, while R_2 and jX_2 represent the impedance of the handset. From this equivalent circuit it can be deduced that the ratio of power radiated by the antenna, P_1 , and the handset, P_2 , is given by

$$\frac{P_1}{P_2} = \frac{R_1}{R_2}$$

If the size of the antenna is reduced, its radiation resistance R_1 will also reduce. If the antenna becomes infinitesimally small its radiation resistance R_1 will fall to zero and all of the radiation will come from the handset. This situation can be made beneficial if the handset impedance is suitable for the source 106 driving it and if the capacitive reactance of the infinitesimal

antenna can be minimised by increasing the capacitive back-coupling to the handset.

With these modifications, the equivalent circuit is modified to that shown in Figure 4. The antenna has therefore been replaced with a physically very small back-coupling capacitor, designed to have a large capacitance for maximum coupling and minimum reactance. The residual reactance of the back-coupling capacitor can be tuned out with a simple matching circuit. By correct design of the handset, the resulting bandwidth can be much greater than with a conventional antenna and handset combination, because the handset acts as a low Q radiating element (simulations show that a typical Q is around 1), whereas conventional antennas typically have a Q of around 50.

A basic embodiment of a capacitively back-coupled handset is shown in Figure 5. A handset 502 has dimensions of 10×40×100mm, typical of modern cellular handsets. A parallel plate capacitor 504, having dimensions 2×10×10mm, is formed by mounting a 10×10mm plate 506 2mm above the top edge 508 of the handset 502, in the position normally occupied by a much larger antenna. The resultant capacitance is about 0.5pF, representing a compromise between capacitance (which would be increased by reducing the separation of the handset 502 and plate 504) and coupling effectiveness (which depends on the separation of the handset 502 and plate 504). The capacitor is fed via a support 510, which is insulated from the handset case 502.

The return loss S_{11} of this embodiment after matching was simulated using the High Frequency Structure Simulator (HFSS), available from Ansoft Corporation, with the results shown in Figure 6 for frequencies f between 1000 and 2800MHz. A conventional two inductor "L" network was used to match at 1900MHz. The resultant bandwidth at 7dB return loss (corresponding to approximately 90% of input power radiated) is approximately 60MHz, or 3%, which is useful but not as large as was required. A Smith chart illustrating the simulated impedance of this embodiment over the same frequency range is shown in Figure 7.

The low bandwidth is because the handset 502 presents an impedance of approximately $3-j90\Omega$ at 1900MHz. Figure 8 shows the resistance variation, over the same frequency range as before, simulated using HFSS. This can be improved by redesigning the case to increase the resistance.

5 One way in which this can be done is to reduce the width of the handset 502, since the resistance will increase in much the same way as that of a dipole when its radius is decreased. Figure 9 shows a second embodiment having a narrow capacitively back-coupled handset 902. The handset 902 has dimensions of $10\times 10\times 100\text{mm}$, while the dimensions of the capacitor 504, 10 formed from the plate 506 and top surface 908 of the handset 902, and the support 510 are unchanged from the previous embodiment. Simulations were again performed to determine the resistance variation of this embodiment, with the results shown in Figure 10. This clearly demonstrates that use of a narrow handset provides a wider bandwidth where the resistance is higher than that of 15 the basic configuration. The length of the handset could be optimised to give a wide bandwidth centred on a particular frequency, by shifting the resonant frequencies of the structure. For a fixed length handset, a horizontal slot (i.e. a slot across the width of the handset) could be used for the purpose of electrically shortening or lengthening the handset.

20 An alternative way of increasing the resistance of the case is the insertion of a vertical slot (i.e. a slot parallel to the length, or major axis, of the handset). Figure 11 shows a third embodiment having a slotted capacitively back-coupled handset 1102, with a 33mm deep slot 1112 in the case, together with a capacitor 504. The dimensions of the capacitor 504, formed from the 25 plate 506 and top surface 1108 of the handset 1102, and the support 510 are unchanged from the previous embodiments. The presence of the slot 1112 significantly increases the resistance of the case, as seen by the transceiver, in the region of 1900MHz, allowing the low-Q case to be matched to 50Ω without a significant loss of bandwidth.

30 The return loss S_{11} of this embodiment was again simulated using HFSS, with the results shown in Figure 12 for frequencies f between 1000 and 2800MHz, using a similar two inductor matching network to that used for the

basic embodiment. The resultant bandwidth at 7dB return loss is greatly improved at approximately 350MHz, or 18%, which is approaching that required to cover UMTS and DCS 1800 bands simultaneously. A Smith chart illustrating the simulated impedance of this embodiment over the same
5 frequency range is shown in Figure 13.

The embodiments disclosed above are based on capacitive coupling. However, any other sacrificial (non-radiating) coupling element could be used instead, for example inductive coupling. Also, the coupling element could be altered in order to aid impedance matching. For example, capacitive coupling
10 could be achieved via an inductive element. This would allow easier matching to yield a more wideband response.

In the above embodiments a conducting handset case has been the radiating element. However, other ground conductors in a wireless terminal could perform a similar function. Examples include conductors used for EMC
15 shielding and an area of Printed Circuit Board (PCB) metallisation, for example a ground plane.

From reading the present disclosure, other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the design, manufacture and use of
20 wireless terminals and component parts thereof, and which may be used instead of or in addition to features already described herein. Although claims have been formulated in this application to particular combinations of features, it should be understood that the scope of the disclosure of the present application also includes any novel feature or any novel combination of
25 features disclosed herein either explicitly or implicitly or any generalisation thereof, whether or not it relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as does the present invention. The applicants hereby give notice that new claims may be formulated to such features and/or combinations of
30 features during the prosecution of the present application or of any further application derived therefrom.

In the present specification and claims the word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements. Further, the word "comprising" does not exclude the presence of other elements or steps than those listed.

CLAIMS

1. A wireless terminal comprising a ground conductor and a transceiver coupled to an antenna feed, wherein the antenna feed is coupled
5 directly to the ground conductor.

2. A terminal as claimed in claim 1, characterised in that the antenna feed is coupled to the ground conductor via a capacitor.

10 3. A terminal as claimed in claim 2, characterised in that the capacitor is a parallel plate capacitor formed by a conducting plate and a portion of the ground conductor.

4. A terminal as claimed in any one of claims 1 to 3, characterised
15 in that a slot is provided in the ground conductor.

5. A terminal as claimed in claim 4, characterised in that the slot is parallel to the major axis of the terminal.

20 6. A terminal as claimed in any one of claims 1 to 5, characterised in that the ground conductor is a handset case.

7. A terminal as claimed in any one of claims 1 to 5, characterised in that the ground conductor is a printed circuit board ground plane.
25

8. A terminal as claimed in any one of claims 1 to 7, characterised in that a matching network is provided between the transceiver and the antenna feed.

30 9. A wireless terminal substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

ABSTRACT**WIRELESS TERMINAL**

5

A wireless terminal comprises a ground conductor (1102) and a transceiver coupled to an antenna feed, the antenna feed being coupled directly to the ground conductor (1102). In one embodiment the ground conductor is a conducting case (1102). The coupling may be via a parallel plate capacitor (504) formed by a plate (506) and a surface (1108) of the case (1102). The case (1102) acts as an efficient, wideband radiator, eliminating the need for a separate antenna. In a modification of this embodiment a slot (1112) is provided to increase the resistance of the case (1102) as seen by the transceiver, thereby increasing the radiating bandwidth of the terminal.

15

(Figure 11)

1/7

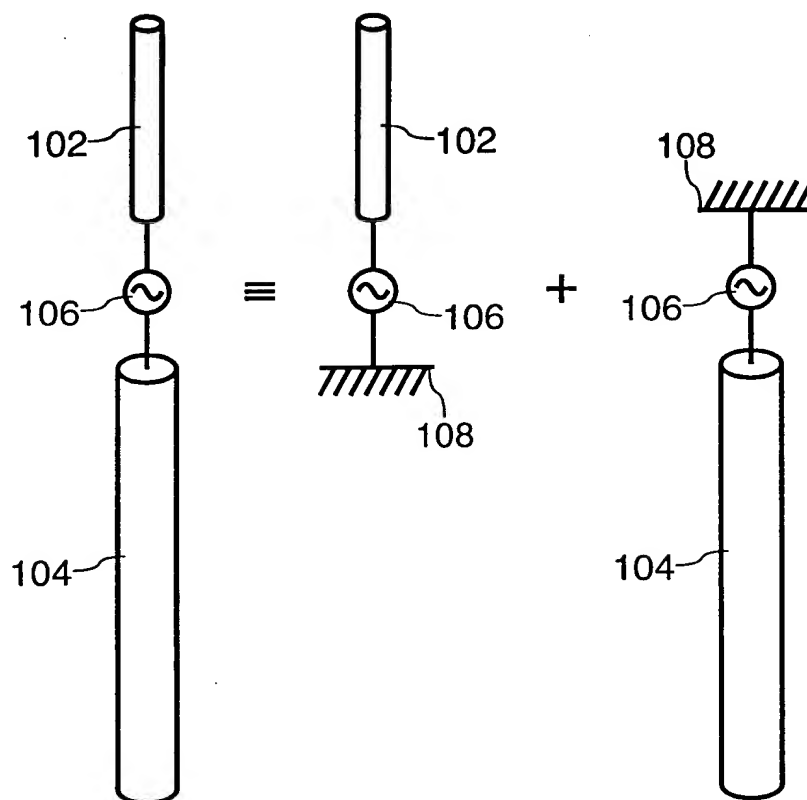


FIG. 1

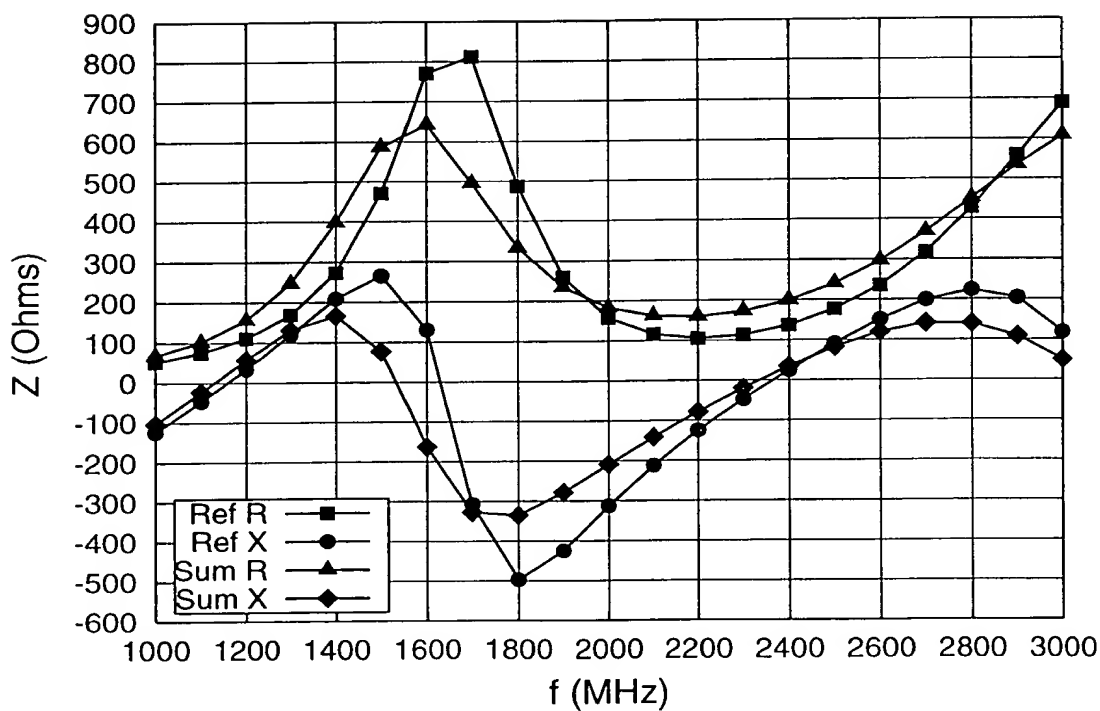


FIG. 2

2/7

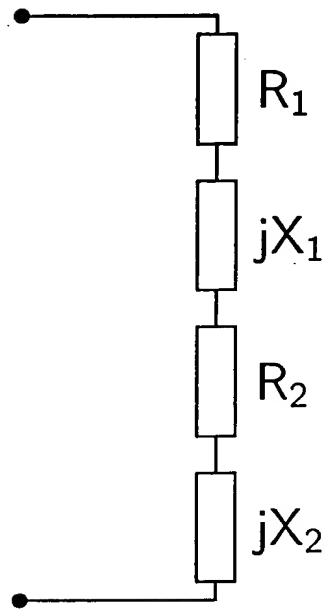


FIG. 3

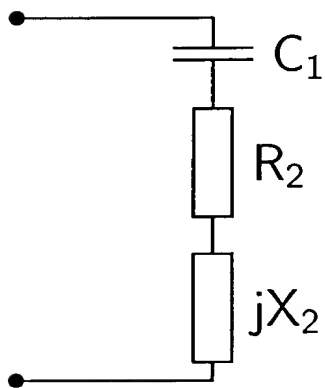


FIG. 4

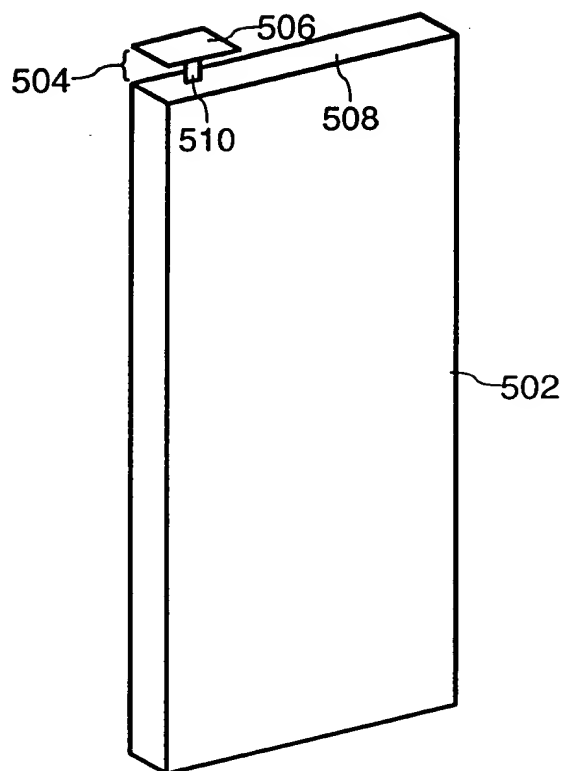


FIG. 5

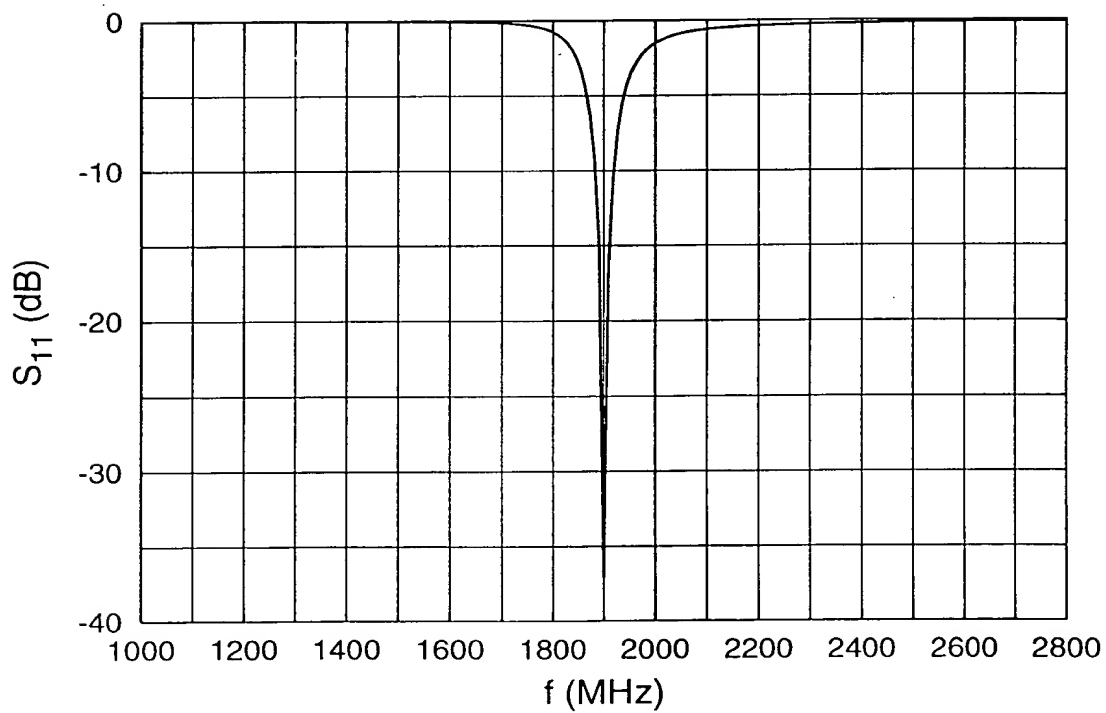


FIG. 6

4/7

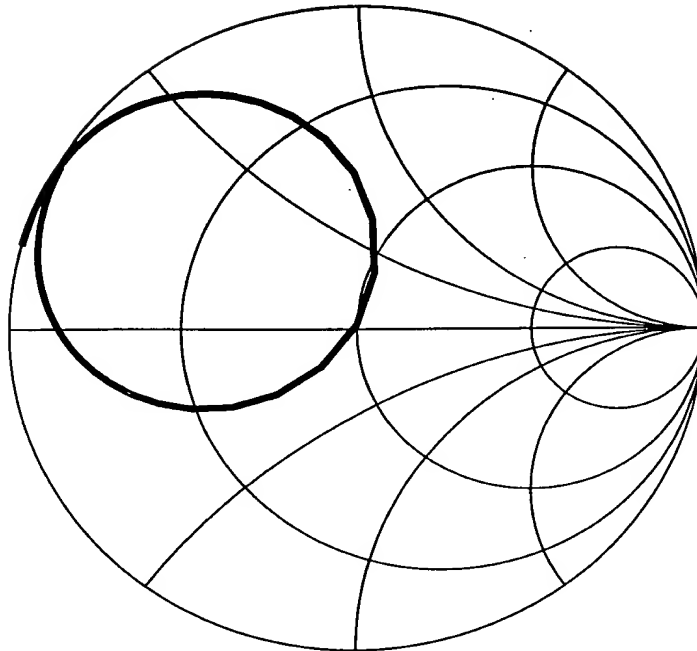


FIG. 7

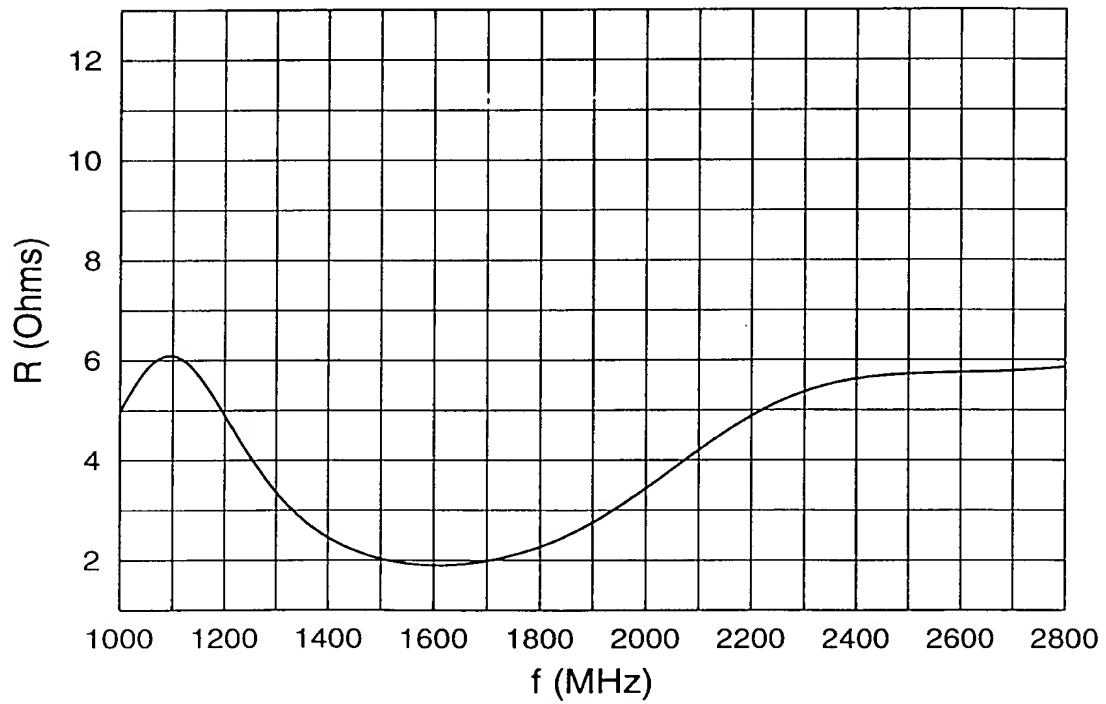


FIG. 8

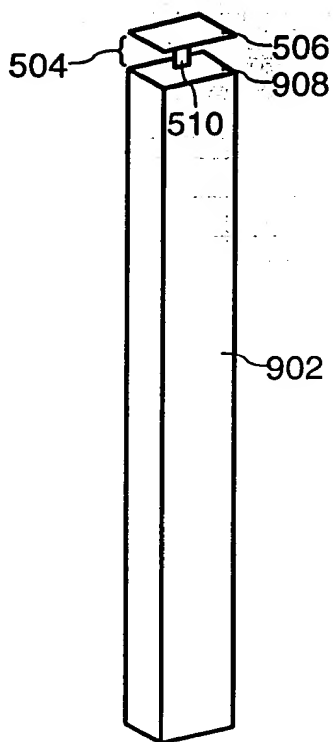


FIG. 9

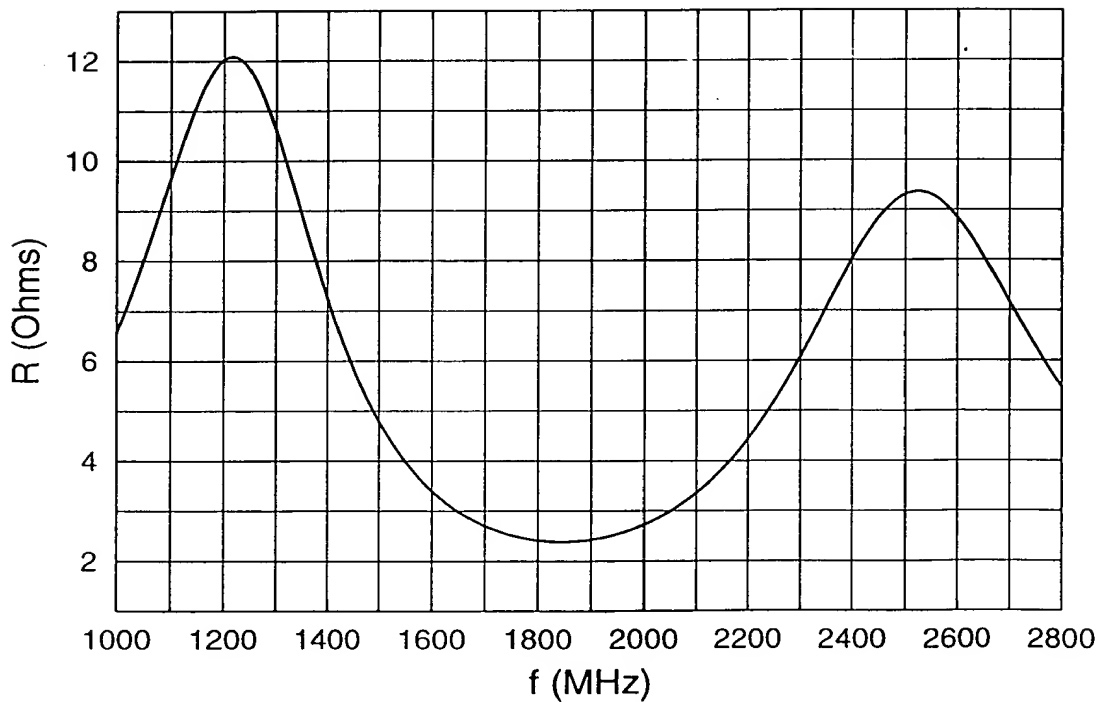


FIG. 10

6/7

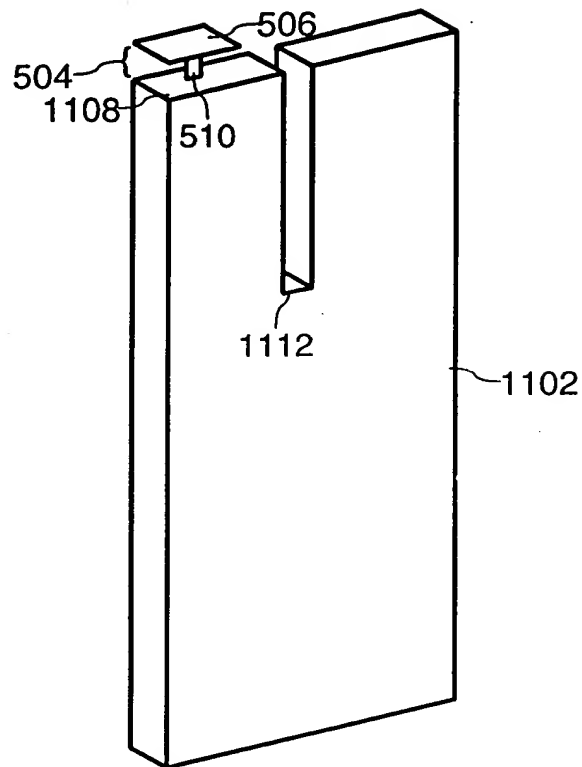


FIG. 11

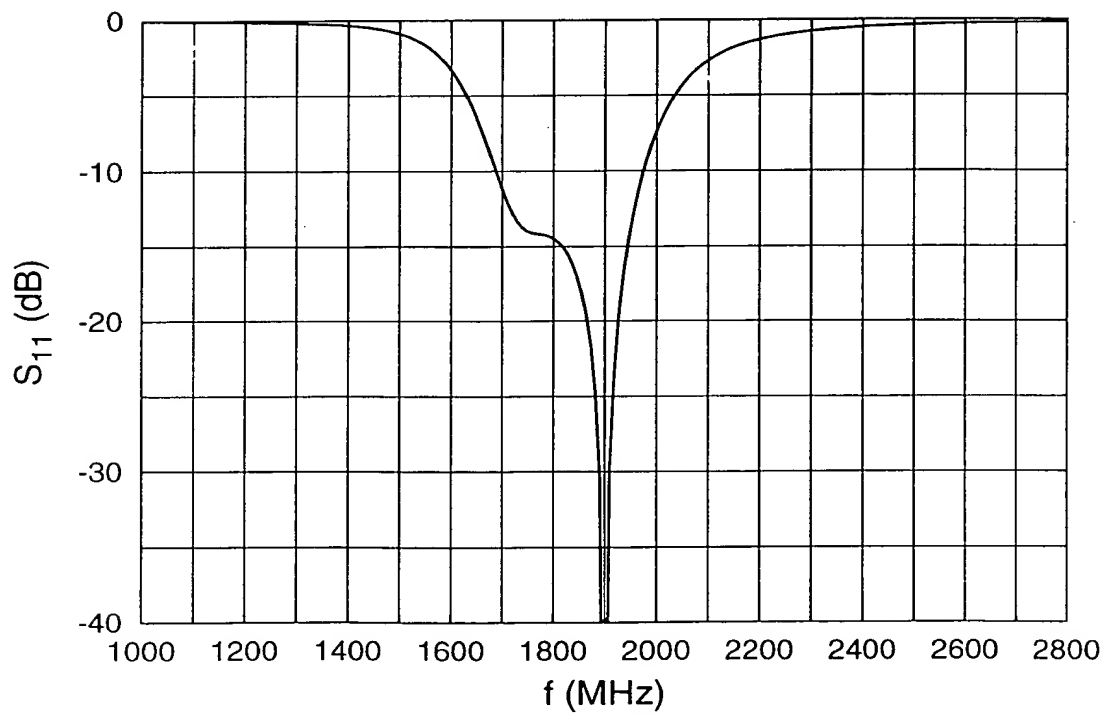
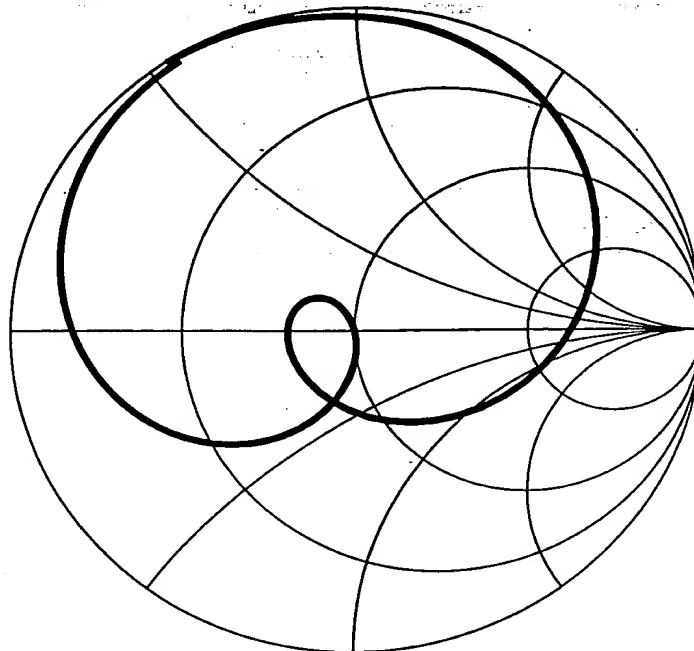


FIG. 12

**FIG. 13**